STATE OF NEW YORK

DEPARTMENT OF CONSERVATION

WATER POWER AND CONTROL COMMISSION

Withdrawal of ground water

on

Long Island, N. Y.

Prepared in co-operation with the United States
Geological Survey, and with Nassau and
Suffolk Count[redacted]

[redacted]

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WITHDRAWAL OF GROUND WATER ON LONG ISLAND, NEW YORK

By David G. Thompson and R. M. Leggette

INTRODUCTION

For many years the ground-water resources of Long Island have been utilized and more or less intensively studied. In recent years the United States Geological Survey, in cooperation with the New York State Water Power and Control Commission and with Nassau and Suffolk Counties, has been carrying on an intensive investigation of these resources. The investigation in all its many phases and the preparation of the results for publication are necessarily slow processes, and for this reason it has seemed desirable to publish the results of separate phases of the work as soon as these phases have progressed sufficiently. The present report deals with the withdrawal or pumpage of ground water, chiefly from wells used for public supply. This phase of the investigation has been pursued in order to obtain basic data on chronologic, geographic, and geologic distribution of withdrawals of ground water and changes in trends of these factors. Although obviously it is closely related to other phases, it is in itself a convenient unit for one report.

In this study the withdrawals for public supply from 1904 to 1934 inclusive in Kings (Brooklyn), Queens, and Nassau Counties have been analyzed, not only chronologically but also according to the source formations. The pumpage from public-supply wells in Suffolk County is so small and so scattered that it has not yet been studied.

In the present report the withdrawals are considered only on an annual basis. A more detailed consideration of the monthly withdrawals from some individual stations is contemplated in a subsequent report describing the nature and cause of the fluctuation of ground-water levels on Long Island. The preparation of the present report has involved a historical study of records of the different water-supply systems to discover the depths of several hundred wells, the formations from which they draw, and changes in these factors from time to time as new wells were drilled and old wells were abandoned.

The study that is here briefly summarized has involved a very large amount of work, and it could not have been made with the funds available

for the general investigation. Fortunately, through the New York City Department of Public Welfare, the New York City Emergency Relief Bureau, and the County Engineer of Nassau County, arrangements were made to have the statistical work done by unemployed engineers paid with funds furnished by Federal, State, county, and city relief agencies. On this basis two men worked on the study most of the time for more than 2 years. At different times the study has been under the direct supervision of Kyle Forrest, W. H. Monroe, or one or the other of the writers.

WATER-BEARING FORMATIONS

It is not within the scope of this report to describe the geology of Long Island. However, for the purpose of this study it has been desirable to divide the water-bearing beds into three major groups based on the geologic age of the water-bearing beds. In a general way such a division also groups together the shallow, intermediate, and deep water-bearing beds.

The most easily developed water-bearing beds on Long Island are those lying nearest the surface throughout most of the island. These are called the post-Jameco beds in this report because they lie above and are geologically younger than the next deeper important water-bearing formation, which is known as the Jameco gravel. They consist of glacial outwash sand and gravel. They have been and will probably continue to be the principal water-bearing beds on the island, because of their widespread occurrence and the fact that in general they are probably more permeable than any of the other formations. In places, however, they may not be satisfactory sources of water--for example, where they are not very thick, or where the water table lies so deep that the saturated portion of the beds is not thick, or in areas so near the coast that in the absence of an overlying protective clay bed salt water may easily gain access to the beds.

In certain areas the post-Jameco beds are underlain by fine sand and clay, which generally are not abundantly water-bearing and below which occurs the Jameco gravel. Where this gravel is well developed it is generally permeable and a good water-bearing formation. However, it is not nearly as widespread as the other water-bearing beds, and the total quantity of water pumped from it is somewhat less than from other formations. The Jameco gravel is believed to have been deposited by streams flowing from the continental glacier when it stood in Long Island Sound, and accordingly this gravel is confined to areas that could be reached by such streams. It is well developed in certain areas in Kings County and Queens County, where a large valley - called the Sound River Valley and perhaps

actually comprising two branch valleys - extended southward from Long Island Sound to Jamaica Bay. It is also found along the north shore of Long Island and a few miles inland in Nassau County and the western part of Suffolk County. It is not present in the interior of Nassau County or Suffolk County, and apparently not on the south shore of these counties. It may be present along the shore at the extreme east end of the island, but that is not yet proved.

In many places beneath the Jameco gravel, or beneath the post-Jameco beds where the Jameco gravel is not present, is a series of water-bearing beds of Cretaceous age. In earlier years the Lloyd sand was the only Cretaceous water-bearing bed definitely recognized. The actual development of the Lloyd sand is probably not as great as might be supposed from the prominence it has occupied in previous discussions of ground-water supplies of Long Island. Nevertheless, it will probably always be an important source of water supply for parts of the island. In recent years good supplies of water have been obtained at several places in Cretaceous beds of sand and gravel that lie several hundred feet above the Lloyd sand. For many localities on Long Island the available data are not yet sufficient to subdivide the Cretaceous beds, and no effort is made to do so in the present report.

USE OF GROUND WATER

The greatest use of ground water on Long Island is for public supply. Water is available from public-supply systems in practically all parts of Kings, Queens, and Nassau Counties. In these areas very little water is used from privately owned wells for domestic purposes, but in Kings County and to a less extent in Queens County large quantities of water for industrial purposes are obtained from private wells.

In Suffolk County public water-supply systems are confined to the more thickly settled territories in or very near to the villages, and a relatively large percentage of the population obtain domestic water supply from individually owned wells. In both Nassau and Suffolk Counties very little ground water is used for industrial purposes, but a comparatively small quantity of water is used for irrigating truck crops.

Within the part of New York City on Long Island, comprising Kings and Queens Counties, water for public supply is furnished largely by the city, but large areas in these counties are served chiefly by two private water companies. The principal territories thus served by private companies are, first, a thickly settled area situated approximately in the center of Kings County, known as the Flatbush territory, which is served by the New York

Water Service Corporation; second, a territory in the southwestern part of Queens County, known as the Woodhaven territory, served by the same corporation; and third, a larger territory in the south-central part of Queens County, known as the Jamaica territory, served by the Jamaica Water Supply Co.

The greater part of the water served to New York City is obtained from upstate surface sources, including the great Catskill system. However, the quantity of ground water served to the Long Island part of New York City is of considerable magnitude. In 1930 the population of Kings and Queens Counties was about 3,640,000, and the total consumption of water for public supply was about 401,000,000 gallons a day. Of this amount about 133,000,000 gallons a day, or more than 33 percent, was derived from ground-water sources. On this basis it is estimated that in 1930 almost 1,250,000 people in the Long Island part of New York City used ground water. The quantity of ground water used for public supply in New York City varies somewhat from year to year, depending largely upon the abundance or scarcity of surface water from the upstate sources. From 1904 to 1934, with the exception of two years, more than 50 percent of the ground water served by New York City in Kings and Queens Counties came from Nassau County. In some of the years the percentage was considerably more than 50 percent.

In Nassau County the population dependent on ground water for public supply in 1930 was about 300,000, and in Suffolk County it was about 160,000.

Water from privately owned wells is extensively used for industrial purposes in Kings and Queens Counties. Unfortunately it has not been possible to compile accurate data for pumpage from private wells, because such information is widely scattered, and adequate records are lacking. However, in connection with hearings on applications to the State Water Power and Control Commission for permission to develop additional water supplies, certain data in regard to private pumpage in Kings and Queens Counties in recent years were compiled jointly by the New York City Department of Water Supply, Gas, and Electricity, the New York Water Service Corporation, and the Jamaica Water Supply Co. On the basis of a comparison with records of industrial employment, T. H. Wiggin, of the New York Water Service Corporation, has estimated the pumpage from private wells for earlier years.[1/]

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1 Wiggin, T. H., Engineering report submitted with brief of counsel for New York Water Service Corporation in the matter of application (No. 681) of the City of New York to the Water Power and Control Commission for the approval of its development and its plans for securing an additional water supply from subsurface sources in the Boroughs of Brooklyn and Queens and in the County of Nassau, table 1, Feb. 26, 1934.

More recently W. F. Laase, of the New York City Department of Water Supply, Gas, and Electricity, has shown that Wiggin's estimates were considerably too low.[2]

The maximum use of ground water in Kings, Queens, and Nassau Counties probably occurred in 1916, when the withdrawals for all public supplies averaged about 188,000,000 gallons a day, and the estimated industrial withdrawals averaged about 75,000,000 gallons a day (Wiggin's estimate), a total use of ground water of about 263,000,000 gallons a day. In 1931 the total use of ground water in the three counties amounted to about 240,000,000 gallons a day, including 185,000,000 gallons for public supplies and about 55,000,000 gallons for industrial purposes (Wiggin's estimates). These figures do not include any estimate for the comparatively small withdrawals from privately owned wells in Nassau County.

SCOPE AND ACCURACY OF DATA

The records of withdrawal on which this report is based were obtained either from the files of the water-supply organizations or from published reports. For some of the smaller water supplies in Nassau County, where no such records were available, it was necessary to estimate the withdrawals. Only about 12 percent of the total withdrawal in Nassau County from 1920 to 1934 by public supply systems not owned by New York City was estimated, and the average daily pumpage estimated ranged from about 6,000,000 gallons in 1929 to about 400,000 gallons in 1932. In other words, of the total daily withdrawal for public supply in Kings, Queens, and Nassau Counties from 1920 to 1934, ranging from 50,000,000 to 184,000,000 gallons, only about 400,000 to 6,000,000 gallons had to be estimated. Thus it is apparent that the probable error resulting from estimates amounts to only a small percentage of the total given.

The withdrawals in Nassau County from 1904 to 1919 by public supply systems not owned by New York City are wholly estimated. From data given by Veatch[3] it is estimated that in 1904 the average daily withdrawal in Nassau County by public water-supply systems not owned by New York City was about 4,000,000 gallons. The same figure is obtained if it is assumed that the withdrawals in Nassau County in 1904 were in the same proportion to the withdrawals in Queens County in 1904 (by the

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2 Laase, W. F., Subsurface water supply of western Long Island and its utilization: Municipal Eng. Jour. New York, Paper 172, p. 51, 1934.

3 Veatch, A. C., and others, Underground water resources of Long Island, N. Y.: U. S. Geol. Survey Prof. Paper 44, pp 82-83, 1906.

Jamaica Water Supply Co. and the New York Water Service Corporation, Woodhaven district) as the respective withdrawals in 1920. The year by year withdrawals by these two systems in Queens County show a gradual and regular increase during this period, and a similar increase has therefore been used in the computations for systems in Nassau County not owned by New York City. Although the estimates of withdrawals from 1904 to 1919 determined by this method are not accurate, they probably give a fair approximation. In any case these quantities are small and do not materially affect the totals.(See fig. 2).

In early years and to a less extent in recent years considerable water for public supply has been withdrawn from ponds, chiefly in Nassau County, by New York City. Strictly speaking, the water in ponds and lakes is surface water in that it occurs on the surface of the earth. The ponds and lakes receive all the direct surface run-off from their drainage basins except as such water is diverted around them. However, surface run-off is small on Long Island as compared with many other localities, and much of the water in the lakes and ponds is ground water that seeps into them. It has been pointed out by earlier workers that these ponds and lakes may be considered huge open wells, because they extend below the water table, and water withdrawn from them is in reality largely ground water. In 1902 the surface run-off entering the Hempstead storage reservoir, one of the chief sources of pond water, was diverted around the reservoir, and since that date essentially no surface run-off has entered the reservoir. Although it is recognized that the water withdrawn from ponds is in large part ground water it has seemed desirable to show the pond-water withdrawals by a different pattern in some of the accompanying illustrations.

Most of the ponds from which water has been withdrawn are located in the so-called Ridgewood system, in the southern part of Queens and Nassau Counties. The water from most of these ponds flows by gravity into a conduit that extends closely parallel to the Montauk branch of the Long Island Railroad from a point near the eastern boundary of Nassau County to the Ridgewood pumping station, in eastern Kings County. This flow of pond water is not accurately measured, but the city keeps a daily record at each pond of the amount of gate opening and the head of water in the pond and in the conduit. In the present study these records were used to compute by the submerged orifice formula the gravity discharge from ponds. The computations were made for Massapequa, Wantagh and Freeport (East Meadow) Ponds and the Hempstead storage reservoir. These ponds are the only ones from which appreciable quantities of water were withdrawn by gravity. The computations were made by groups of consecutive days

during which there was but little change in gate opening or head in the pond or conduit. The water from some of the ponds is pumped to the conduit, and the records of this pumpage are of course included in the figures given for total pond withdrawal. The water from Watts Pond, until it was abandoned in 1917, was pumped to the conduit together with the water from the Watts Pond wells, the pumpage from the two sources not being separated. Half of this combined pumpage was assumed to be pond water.

The amount of water withdrawn at the pumping stations in the Ridgewood system was determined by the pump-displacement method. The determination of pumpage in this way is subject to considerable error, as well as to considerable variation in the degree of error from time to time as the pumps are repacked. If the records were accurate, the sum of the withdrawals from the pumping stations along the conduit and the gravity discharge from the ponds should represent the total withdrawal from the Ridgewood system. The water delivered to the distribution system, however, is measured by venturi meters at two booster stations, and frequently these records do not check with the sum of the records of the pumping stations and gravity ponds. This is doubtless due to inaccuracies in computing the withdrawals from the pumping stations and gravity ponds, to loss or gain by leakage along the conduit, to changes in conduit storage, etc. The figures given in this report, so far as they concern withdrawals by New York City in the Ridgewood system, are based on venturi-meter records. The difference between these records and the sum of the records of the pumping stations and gravity ponds has been distributed on a percentage basis between the ground-water withdrawals and the pond withdrawals. Thus the total height of the columns in figure 1 is fairly accurate, but the position of the boundaries between the bars representing pond water and ground water is less accurate. The pond withdrawals represented, however, are believed to show the general order of magnitude and permit fairly accurate year by year comparisons.

At one time or another during the 31 years 1904 to 1934 many different public water-supply units have been operated in numerous localities. (See fig. 6.) Some of these pumping units consist of groups of a few to many wells that are pumped by a central suction pump. Other units consist of only one well pumped by an individual pump. Still others consist of infiltration galleries pumped from a central well. At different times during the 31-year period New York City operated a total of 48 ground-water pumping units--5 in Kings County, 30 in Queens County, and 13 in Nassau County. During the same period 34 public water-supply systems not owned by New York City operated 162 ground-water pumping

units--31 in Kings County, 57 in Queens County, and 74 in Nassau County. During 1931, a year of heavy draft, New York City operated 29 ground-water pumping units--3 in Kings County, 18 in Queens County, and 8 in Nassau County. During the same year 31 public water-supply systems not owned by New York City operated 126 ground-water pumping units--20 in Kings County, 36 in Queens County, and 70 in Nassau County.

CHANGE IN RATE OF WITHDRAWAL SINCE 1904

The following table shows the average daily withdrawal in Kings, Queens, and Nassau Counties for the period 1904 to 1934, and figure 1 shows the same data graphically. The total withdrawal in the three counties for public supply has varied considerably from year to year, owing largely to variations in the use of ground water to meet the deficiencies in the upstate surface-water sources.

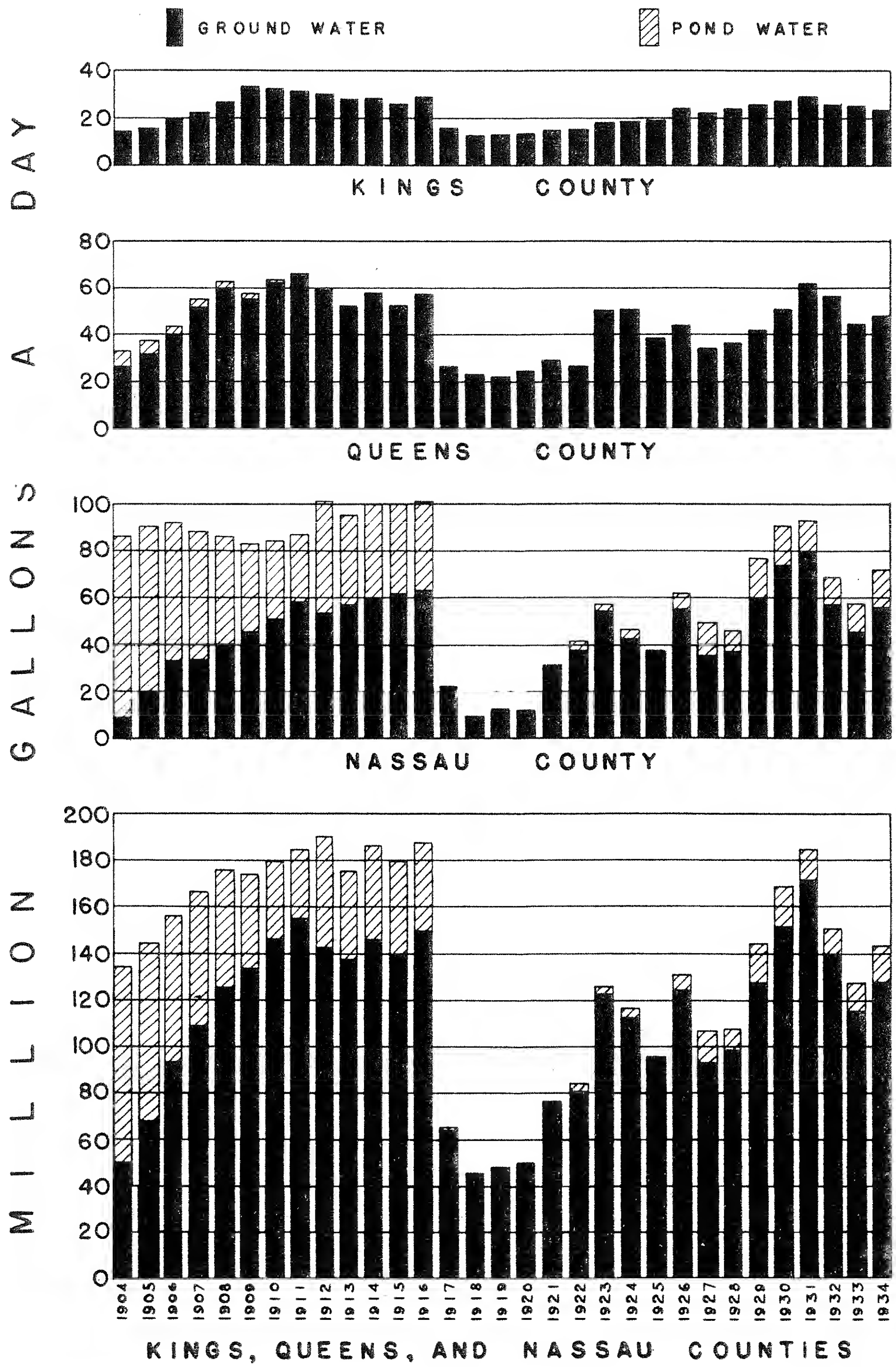

FIGURE 1.–GRAPHS SHOWING AVERAGE DAILY WITHDRAWAL OF WATER FOR PUBLIC SUPPLY IN KINGS, QUEENS, AND NASSAU COUNTIES, NEW YORK

Summary of average daily withdrawal of water for public supply in Kings, Queens, and Nassau Counties, N. Y., by New York City and other systems, in million gallons

Year	Ground water					
	Kings County			Queens County		
	N.Y. City system	Other systems	Total	N.Y. City system	Other systems	Total
1904	8.86	5.90	14.76	15.78	11.16	26.94
1905	9.07	6.90	15.97	20.50	11.84	32.34
1906	10.00	9.90	19.90	26.71	13.64	40.35
1907	11.84	10.80	22.64	37.17	15.04	52.21
1908	14.02	13.00	27.02	43.60	15.57	59.17
1909	18.47	14.30	32.77	39.20	16.07	55.27
1910	17.40	15.10	32.50	45.79	16.69	62.48
1911	16.73	14.90	31.63	44.98	20.18	65.16
1912	14.56	15.50	30.06	38.27	20.79	59.06
1913	12.05	16.00	28.05	32.72	19.36	52.08
1914	12.41	15.90	28.31	42.15	15.87	58.02
1915	12.29	14.10	26.39	36.73	15.71	52.44
1916	14.65	14.60	29.25	38.58	18.61	57.19
1917	2.01	14.40	16.41	7.09	19.20	26.29
1918	0	13.10	13.10	.05	23.06	23.11
1919	.30	13.00	13.30	.23	22.22	22.45
1920	.37	13.50	13.87	0	24.45	24.45
1921	.83	14.52	15.35	4.35	25.09	29.44
1922	.19	15.49	15.68	7.34	19.39	26.73
1923	2.34	16.24	18.58	32.76	17.53	50.29
1924	1.23	17.65	18.88	31.07	19.80	50.87
1925	0	19.27	19.27	17.56	21.01	38.57
1926	2.87	21.67	24.54	21.49	22.66	44.15
1927	0	22.49	22.49	11.74	23.00	34.74
1928	0	24.69	24.69	13.44	23.50	36.94
1929	0	25.91	25.91	16.51	25.53	42.04
1930	.51	26.55	27.06	22.01	28.81	50.82
1931	4.80	24.36	29.16	33.92	28.03	61.95
1932	.68	25.17	25.85	26.12	30.31	56.43
1933	.01	25.21	25.22	13.97	30.91	44.88
1934	0	23.75	23.75	16.97	30.81	47.78
1904-16	13.26	12.84	26.10	35.55	16.20	51.75
1917-34	.90	19.83	20.73	15.37	24.18	39.55
1904-34	6.08	16.90	22.98	23.83	20.83	44.67

Summary of average daily withdrawal of water for public supply in Kings, Queens, and Nassau Counties, N. Y., by New York City and other systems, in million gallons--Continued

Year	Ground water						Pond Water, New York City	Total
	Nassau County			Kings, Queens and Nassau Counties				
	N.Y. City system	Other systems	Total	N.Y. City system	Other systems	Total		
1904	5.07	4.00	9.07	29.71	21.06	50.77	83.74	134.51
1905	15.44	4.20	19.64	45.01	22.94	67.95	76.32	144.27
1906	28.42	4.70	33.12	65.13	28.24	93.37	62.61	155.98
1907	28.60	5.10	33.70	77.61	30.94	108.55	57.69	166.24
1908	34.05	5.40	39.45	91.67	33.97	125.64	50.46	176.10
1909	39.50	6.00	45.50	97.17	36.37	133.54	40.23	173.77
1910	44.78	6.20	50.98	107.97	37.99	145.96	34.70	180.66
1911	51.55	6.80	58.35	113.26	41.88	155.14	29.43	184.57
1912	46.20	7.30	53.50	99.03	43.59	142.62	47.63	190.25
1913	49.50	7.60	57.10	94.27	42.96	137.23	38.03	175.26
1914	51.75	8.00	59.75	106.31	39.77	146.08	40.13	186.21
1915	53.43	8.50	61.93	102.45	38.31	140.76	38.92	179.68
1916	54.62	8.70	63.32	107.85	41.91	149.76	37.80	187.56
1917	11.90	9.40	21.30	21.00	43.00	64.00	1.09	65.09
1918	0	9.80	9.80	.05	45.96	46.01	0	46.01
1919	2.54	10.40	12.94	3.07	45.62	48.69	0	48.69
1920	1.48	10.60	12.08	1.85	48.55	50.40	0	50.40
1921	20.27	11.40	31.67	25.45	51.01	76.46	0	76.46
1922	25.70	12.20	37.90	33.23	47.08	80.31	3.54	83.85
1923	40.90	13.80	54.70	76.00	47.57	123.57	3.02	126.59
1924	26.20	16.10	42.30	58.50	53.55	112.05	4.35	116.40
1925	18.76	19.00	37.76	36.32	59.28	95.60	0	95.60
1926	32.94	22.60	55.54	57.30	66.93	124.23	6.96	131.19
1927	11.30	24.40	35.70	23.04	69.89	92.93	13.90	106.83
1928	11.75	25.20	36.95	25.19	73.39	98.58	9.12	107.70
1929	27.40	32.50	59.90	43.91	83.94	127.85	17.12	144.97
1930	39.42	34.40	73.82	61.94	89.76	151.70	17.00	168.70
1931	46.91	33.10	80.01	85.63	85.49	171.12	13.40	184.52
1932	25.68	31.90	57.58	52.48	87.38	139.86	11.02	150.88
1933	15.42	29.70	45.12	29.40	85.82	115.22	12.58	127.80
1934	24.17	31.70	55.87	41.14	86.26	127.40	16.02	143.42
1904-16	38.69	6.35	45.03	87.50	35.38	122.88	49.05	171.93
1917-34	21.26	21.01	42.27	37.53	65.03	102.55	7.17	109.73
1904-34	28.57	14.86	43.43	58.48	52.59	111.08	24.74	135.81

Water from the Catskill system of New York City was first served to Kings and Queens Counties in January 1917, and the withdrawal of ground water on Long Island was therefore considerably reduced, as shown in figure 1. However, in 1921 the withdrawal of ground water by the city again began to increase and in 1923 a secondary peak was reached. In February 1924 more upstate surface water was made available by the delivery of Schoharie Creek water through the Shandaken tunnel. The demand for Long Island ground water therefore decreased somewhat during 1924 and 1925, but in 1926 another secondary peak was reached. Additional upstate surface water was again made available by the completion of the Schoharie reservoir in 1926. The demand for Long Island ground water again decreased, but in 1931 a major peak was again reached, undoubtedly owing in part to the drought of 1930-31. The downward trend from 1931 to 1933 was perhaps in part the result of the depression and no doubt in part due to more normal precipitation and the availability of greater quantities of upstate surface water. Figure 2, in which the withdrawals by New York City are plotted separately, shows the trends just described in more detail.

These same trends are likewise apparent in the graphs showing the withdrawals in each of the three counties, particularly in Nassau County. It is worthy of note that in the earlier years withdrawal from ponds in Nassau County gradually decreased at about the same rate as the pumpage from wells and galleries increased.

It should be kept in mind that the graphs accompanying this report do not include industrial pumpage. If Laase's estimates for industrial pumpage in 1933 (Kings County 50,000,000 gallons a day, Queens County 25,000,000 gallons a day) were added to the public-supply withdrawals in 1933 as shown in figure 1, the column for Kings County would be about three times as high as that shown, and the column for Queens County about half again as high.

It is apparent from figure 1 that in spite of the large additional quantity of water made available by the development of upstate surface sources, the demands on Long Island ground water for public supply were approximately the same in the recent peak years as in 1910 to 1916.

WITHDRAWAL BY NEW YORK CITY COMPARED WITH OTHER PUBLIC WATER-SUPPLY SYSTEMS

For various reasons it has seemed desirable to compare the withdrawals by New York City with those of all other public-supply systems. Figure 2 shows this comparison and a previous table gives the average daily withdrawal by New York City and other systems.

In April 1922 New York City acquired stations belonging to the Citizens' Water Supply Co. In figure 2 the withdrawals from these stations prior to this change of ownership are included in the columns for systems not owned by New York City, and the withdrawals after this change are included in the columns for New York City. The withdrawals from these stations in 1921 averaged about 10,000,000 gallons a day and in 1923 less than 6,000,000 gallons a day. If this change of ownership had not taken place the 1922 and 1923 columns for withdrawal by New York City in Queens County, as shown in figure 2, would have been smaller and the columns for other water-supply systems would have been larger. Thus the transfer of withdrawals from these stations from one column to the other after April 1922 somewhat changes the comparison of the two columns. Other changes of ownership have taken place, but they involved only small quantities of water.

The major trends as shown in figure 1 are caused by variations in use of upstate surface water by New York City. In figure 2 the withdrawals by New York City show in greater detail the effect of variations in use of upstate surface water. As noted on page 14, the availability of Catskill water in 1917, 1924, and 1926 considerably reduced the demands on Long Island ground water. During 1918, 1919, and 1920 New York City used a very small amount of Long Island ground water, but thereafter its withdrawals considerably increased, varying chiefly with the availability of upstate surface water. New York City has withdrawn very little ground water from Kings County since Catskill water became available, but in Queens and Nassau Counties its withdrawals have been large, particularly in 1930 and 1931.

The withdrawals by water-supply systems not owned by New York City show a year by year trend unaffected by variations in use of upstate surface water. With minor exceptions, the upward trend for the three counties together is fairly uniform, the flattening off in the last 5 years presumably being the result of the depression. It is worthy of note that the more or less uniform upward trend since about 1923 shown in figure 2 is chiefly the result of greater withdrawals in Nassau County,

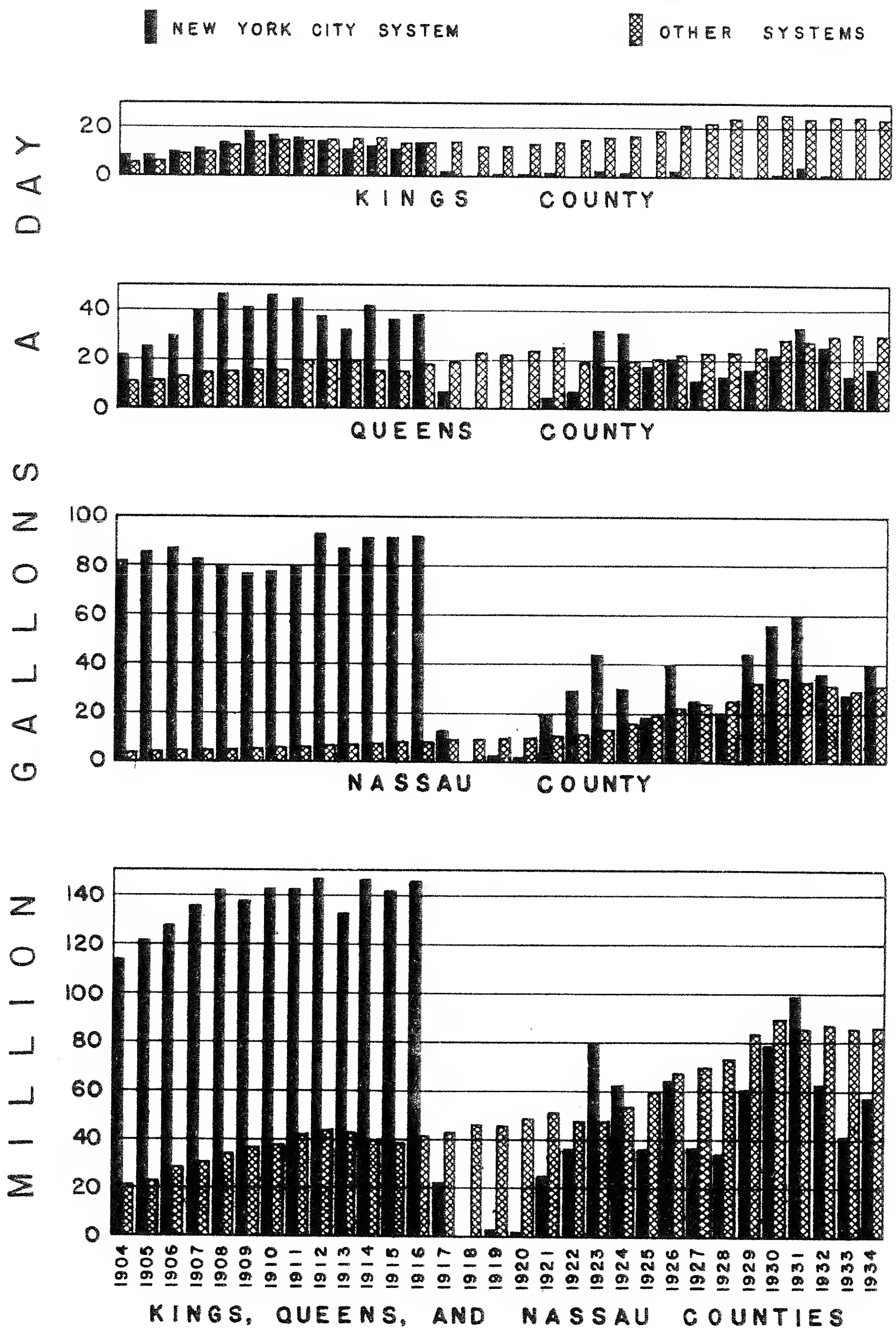

FIGURE 2.- GRAPHS SHOWING AVERAGE DAILY WITHDRAWAL OF WATER FOR PUBLIC SUPPLY IN KINGS, QUEENS, AND NASSAU COUNTIES, N.Y. BY NEW YORK CITY AND OTHER SYSTEMS

where during the decade between 1920 and 1930 there was an increase in population of about 140 percent. However, in Kings County there has been a more or less gradual upward trend since about 1920, though not as marked as in Nassau County. The withdrawals in Queens County were about 23 percent greater in recent peak years than in 1921.

A further comparison of the withdrawals by New York City and other water-supply systems is shown in figure 3. It is apparent that in the 13-year period 1904 to 1916 (before Catskill water became available) the withdrawals by New York City far exceeded those of all other water-supply systems combined, except in Kings County, where the difference was slight. During the 18-year period 1917 to 1934, however, the withdrawals by water-supply systems not owned by New York City were considerably greater than those of New York City in Kings and Queens Counties. Although New York City's withdrawals in Nassau County during this period were greater than those of other water-supply systems, the total for the three counties combined shows considerably smaller withdrawals by New York City than by other water-supply systems. For the 31-year period 1904 to 1934 the average withdrawal by New York City was considerably greater than that of all other water-supply systems combined. If it becomes necessary for the city to increase its use of ground water considerably until additional upstate surface water becomes available, it may be expected that the withdrawal by the city will again more nearly approach and perhaps exceed that by other systems.

WITHDRAWALS FROM THE DIFFERENT SOURCE FORMATIONS

The subdivision of the source formations into three groups, for the purpose of this report, is described in the section on water-bearing formations. The geologic age of the formations that yield the water in some localities is not definitely known, because of the absence of accurate well logs and the difficulty of making accurate correlations. Nevertheless, it seemed desirable to subdivide the total withdrawal for public supply on the basis of the three source formations.

For several reasons the subdivision is only approximate. In some of the well fields the wells of different depths draw from two or more formations, but there are no data as to the relative quantities of water pumped from the different wells, nor as to the diameters or lengths of the screens or other factors required to determine the relative yield of the different wells. For such well fields the pumpage from the different formations has been distributed in direct proportion to the number of

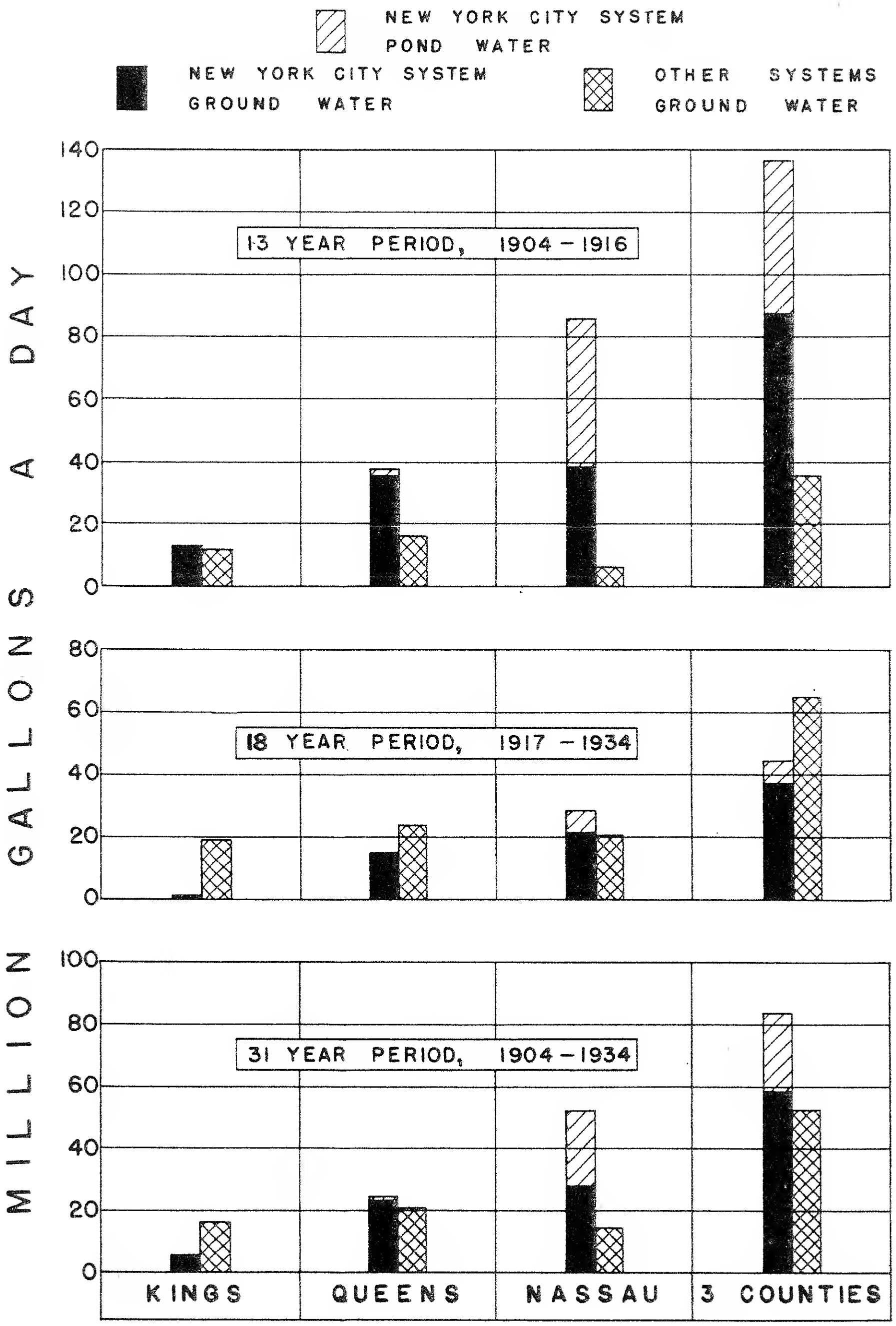

FIGURE 3.- GRAPHS SHOWING AVERAGE DAILY WITHDRAWAL OF WATER FOR PUBLIC SUPPLY IN KINGS, QUEENS, AND NASSAU COUNTIES, N.Y., BY NEW YORK CITY AND OTHER SYSTEMS FOR THREE PERIODS OF YEARS

wells drawing from the respective formations. Although this method obviously does not give very exact results, it is believed to show with a fair degree of accuracy the comparative draft from the formations. However, as shown by figure 6 most of the water in any given locality is taken from well fields that draw from a single formation. The withdrawal from these fields is therefore not subject to the inaccuracy noted above.

The following table shows the average daily withdrawal from the different source formations in Kings, Queens, and Nassau Counties from 1904 to 1934, and figure 4 shows the same data graphically. Figure 5 shows this same subdivision on a percentage basis. Although most of the water withdrawn from ponds is ground water and therefore should be considered withdrawal from the post-Jameco beds, it has been shown separately in the illustrations. Thus the percentage of the total withdrawal for public supply from the post-Jameco beds is approximately the sum of the percentages shown by the two patterns of diagonal shading in figure 5. In considering this graph it should be noted that a change in percentage of withdrawal from any one of the source formations from year to year may be either the result of an actual change in quantity of water pumped from the formation (greater or less pumpage from existing wells or operation of new wells or abandonment of existing wells) or a change in proportion to the total pumpage from all formations. This is evident from a comparison of figures 4 and 5.

Summary of average daily withdrawal of water for public supply from the different source formations in Kings, Queens, and Nassau Counties, N. Y., in million gallons

Year	Kings County			Queens County			
	Post-Jameco	Jameco	Creta-ceous	Ponds	Post-Jameco	Jameco	Creta-ceous
1904	14.15	0.61	0	6.36	23.22	3.72	0
1905	15.33	.64	0	5.64	27.83	3.93	.58
1906	19.13	.77	0	3.61	35.60	3.85	.90
1907	21.58	1.06	0	3.02	41.76	7.56	2.89
1908	20.83	6.19	0	3.68	43.62	12.26	3.29
1909	23.67	8.98	.12	2.53	40.94	10.82	3.51
1910	24.11	7.94	.45	1.05	45.96	12.47	4.05
1911	23.63	7.56	.44	.62	44.33	13.07	7.76
1912	22.94	6.67	.45	0	39.21	10.63	9.22
1913	22.37	5.32	.36	0	33.37	11.12	7.59
1914	22.75	5.20	.36	0	37.61	13.27	7.14
1915	20.06	5.96	.37	0	32.56	13.21	6.67
1916	22.05	6.78	.42	0	36.94	13.33	6.92
1917	15.87	.48	.06	0	17.34	3.58	5.37
1918	13.10	0	0	0	16.14	1.73	5.24
1919	13.26	.04	0	0	15.37	1.83	5.25
1920	13.87	0	0	0	16.23	2.03	6.19
1921	15.35	0	0	0	17.90	4.71	6.83
1922	15.68	0	0	0	19.54	1.56	5.63
1923	17.22	1.36	0	0	36.11	11.82	2.36
1924	17.77	1.11	0	0	33.10	8.85	8.92
1925	19.27	0	0	0	26.51	3.41	9.07
1926	23.94	.35	.25	0	30.97	6.17	7.01
1927	21.31	.74	.44	0	26.53	3.08	5.13
1928	23.44	.83	.42	0	26.63	3.76	6.55
1929	22.68	2.71	.52	0	29.32	3.95	8.77
1930	17.51	6.99	2.56	0	34.59	6.71	9.52
1931	13.21	12.92	3.03	0	33.13	12.29	16.53
1932	9.48	14.82	1.55	0	33.84	9.83	13.76
1933	9.45	14.94	.83	0	26.45	5.71	12.72
1934	10.68	12.48	.59	0	27.19	6.74	13.85
1904-16	20.97	4.90	.23	2.04	37.15	9.94	4.66
1917-34	16.28	3.88	.57	0	25.87	5.43	8.26
1904-34	18.25	4.30	.43	.86	30.57	7.32	6.75

Summary of average daily withdrawal of water for public supply from the different source formations in Kings, Queens, and Nassau Counties, N. Y., in million gallons--Continued

Year	Nassau County				Kings, Queens, and Nassau Counties			
	Ponds	Post-Jameco	Jameco	Cretaceous	Ponds	Post-Jameco	Jameco	Cretaceous
1904	77.38	8.57	0.25	0.25	83.74	45.94	4.58	0.25
1905	70.68	18.12	.25	1.27	76.32	61.28	4.82	1.85
1906	59.00	30.90	.25	1.97	62.61	85.63	4.87	2.87
1907	54.67	32.07	.25	1.38	57.69	95.41	8.87	4.27
1908	46.78	38.00	.25	1.20	50.46	102.45	18.70	4.49
1909	37.70	43.28	.30	1.92	40.23	107.89	20.10	5.55
1910	33.65	46.42	.30	4.26	34.70	116.49	20.72	8.76
1911	28.81	52.90	.30	5.15	29.43	120.86	20.93	13.35
1912	47.63	48.96	.30	4.24	47.63	111.11	17.60	13.91
1913	38.03	53.64	.35	3.11	38.03	109.38	16.79	11.06
1914	40.13	55.07	.35	4.33	40.13	115.43	18.82	11.83
1915	38.92	57.37	.37	4.19	38.92	109.99	19.54	11.23
1916	37.80	58.06	.37	4.89	37.80	117.05	20.48	12.23
1917	1.09	19.40	.40	1.50	1.09	52.61	4.46	6.93
1918	0	8.40	.40	1.00	0	37.64	2.13	6.24
1919	0	11.44	.40	1.10	0	40.07	2.27	6.35
1920	0	10.58	.40	1.10	0	40.68	2.43	7.29
1921	0	29.87	.50	1.30	0	63.12	5.21	8.13
1922	3.54	35.95	.60	1.35	3.54	71.17	2.16	6.98
1923	3.02	51.09	.70	2.91	3.02	104.42	13.88	5.27
1924	4.35	37.70	.80	3.80	4.35	88.57	10.76	12.67
1925	0	33.47	.80	3.49	0	79.25	4.21	12.14
1926	6.96	48.98	.90	5.66	6.96	103.89	7.42	12.92
1927	13.90	26.40	1.10	8.20	13.90	74.24	4.92	13.77
1928	9.12	25.42	1.20	10.33	9.12	75.49	5.79	17.30
1929	17.12	42.11	1.70	16.09	17.12	94.11	8.36	25.36
1930	17.00	54.10	1.70	18.02	17.00	106.20	15.40	30.10
1931	13.40	60.02	1.60	18.39	13.40	106.36	26.81	37.95
1932	11.02	37.50	1.70	18.38	11.02	79.82	26.35	33.69
1933	12.58	26.78	1.40	16.94	12.58	62.68	22.05	30.49
1934	16.02	36.78	1.54	17.55	16.02	74.65	20.76	31.99
1904-16	47.01	41.80	.30	2.94	49.05	99.92	15.14	7.82
1917-34	7.17	33.11	.99	8.17	7.17	75.26	10.30	17.00
1904-34	23.88	36.75	.70	5.98	24.74	85.60	13.09	13.15

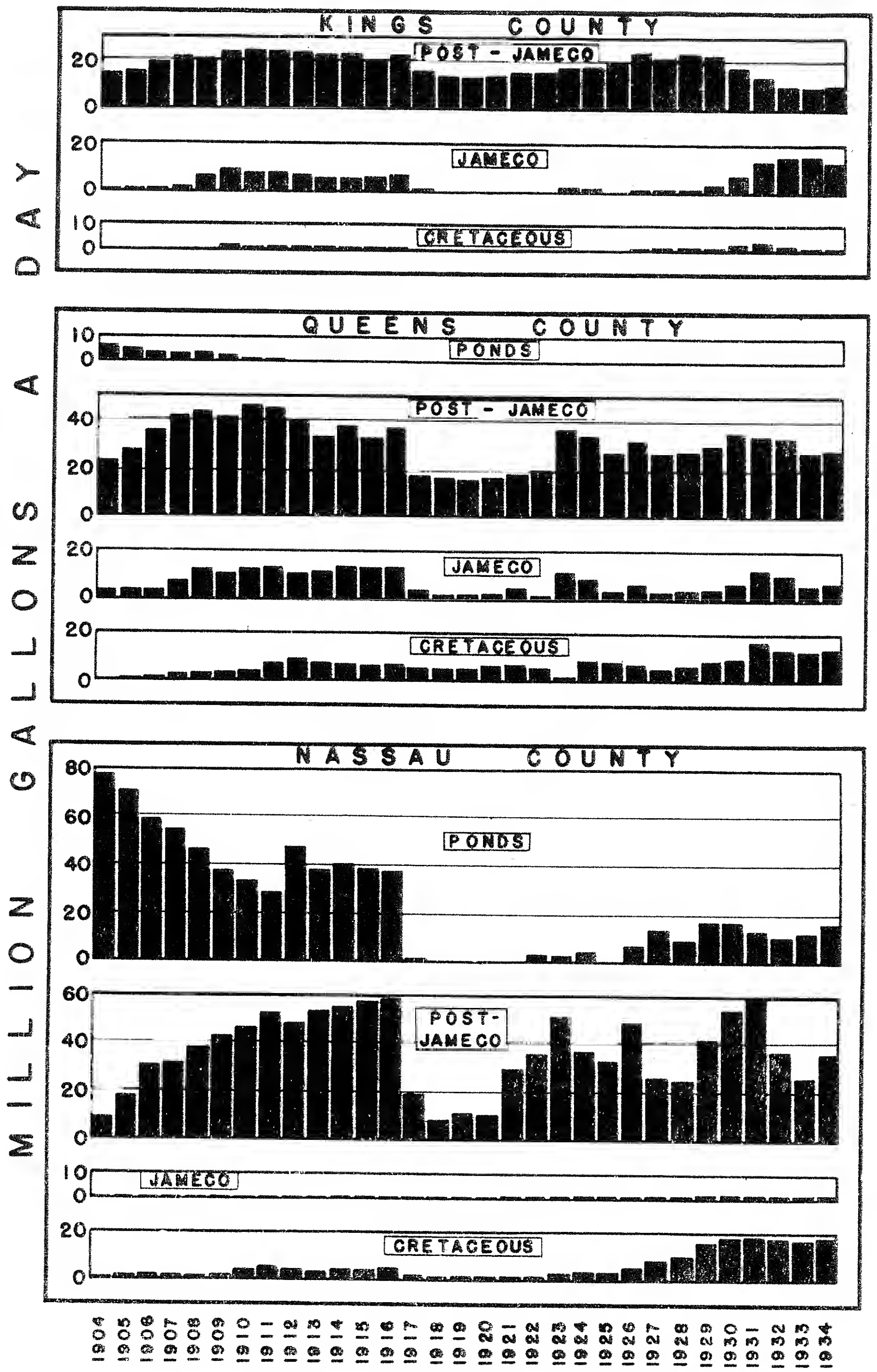

FIGURE 4.- GRAPHS SHOWING AVERAGE DAILY WITHDRAWAL OF WATER FOR PUBLIC SUPPLY FROM THE DIFFERENT SOURCE FORMATIONS IN KINGS, QUEENS, AND NASSAU COUNTIES, N.Y.

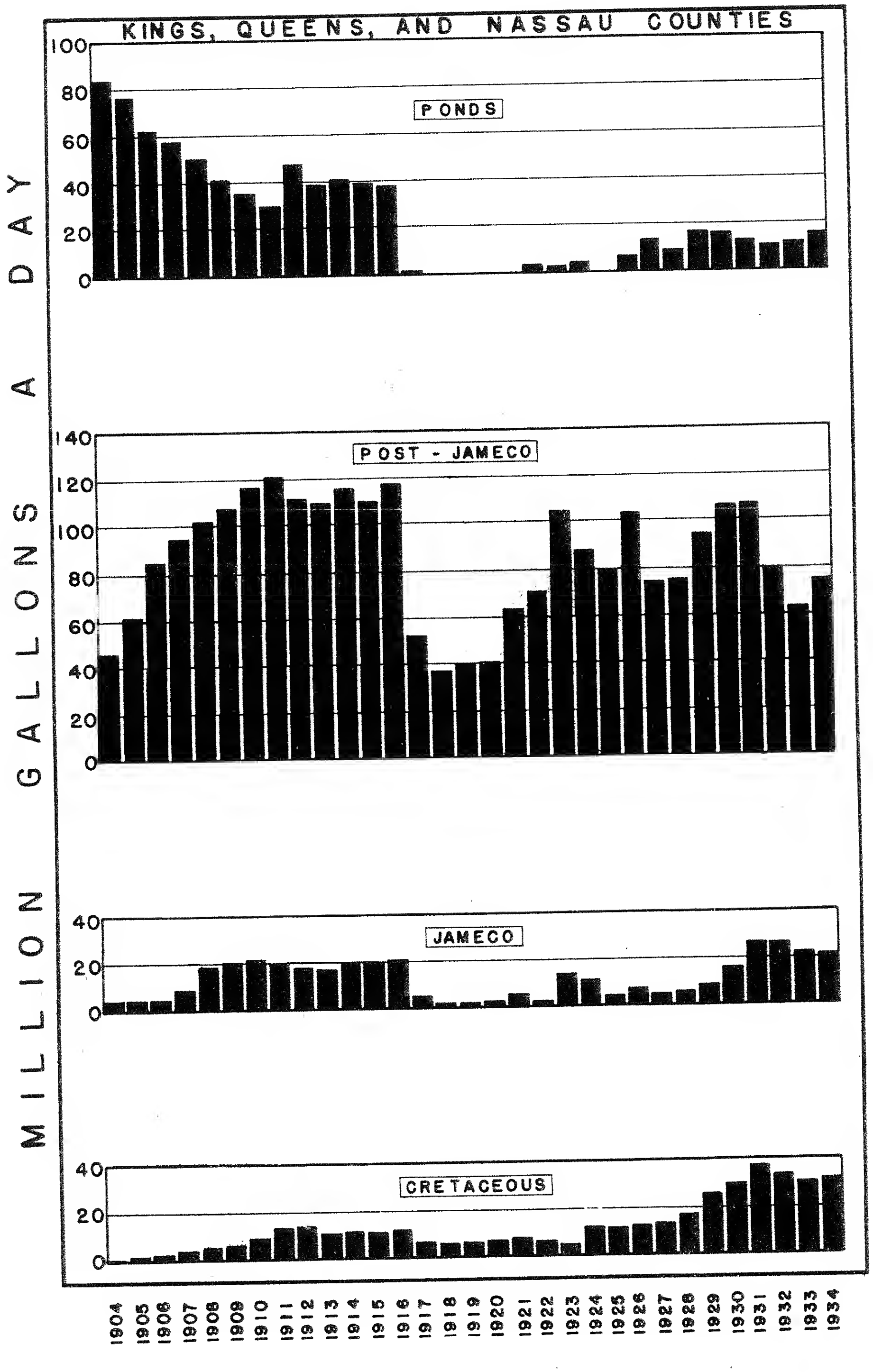

FIGURE 4.- GRAPHS SHOWING AVERAGE DAILY WITHDRAWAL OF WATER FOR PUBLIC SUPPLY FROM THE DIFFERENT SOURCE FORMATIONS IN KINGS, QUEENS, AND NASSAU COUNTIES, N.Y.- CONTINUED

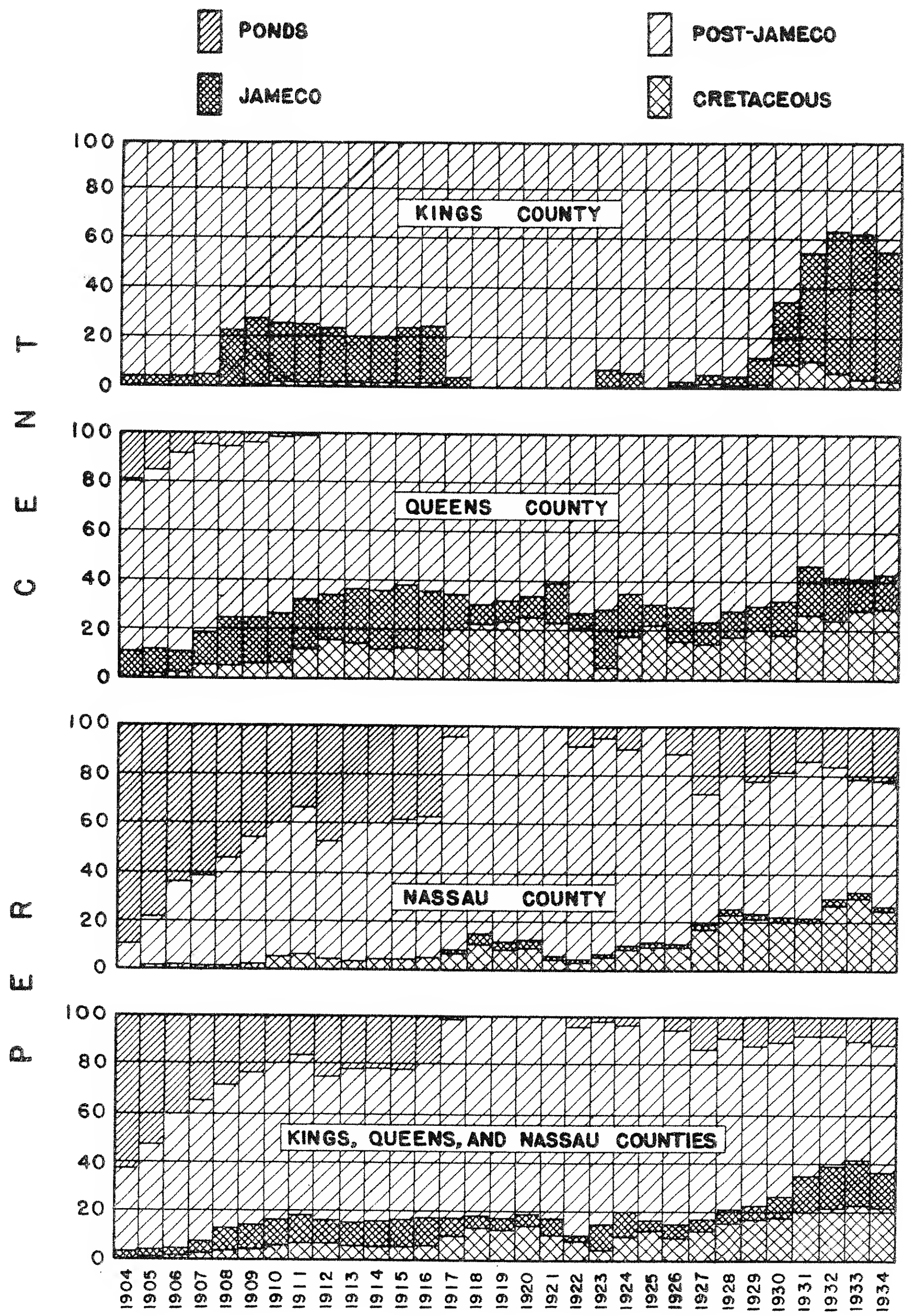

FIGURE 5. - GRAPHS SHOWING PERCENTAGE OF WATER FOR PUBLIC SUPPLY DERIVED FROM THE DIFFERENT SOURCE FORMATIONS IN KINGS, QUEENS, AND NASSAU COUNTIES, N.Y.

Figure 6 shows approximately the average daily withdrawal and the location of well fields from which water was withdrawn at each of the public water-supply pumping stations in the three counties in 1930. Some of the circles have been spread out to prevent overlap. Where the records of withdrawal from more than one station were reported as a combined figure, they have been shown on the map as one circle. For example, the circle for the Jericho water district, in the northeastern part of Nassau County, represents pumpage from four separate wells. At the two localities of largest withdrawal--namely, the Wantagh gallery and the Massapequa gallery of New York City, in Nassau County--the large quantities indicated are not taken from groups of wells in comparatively small areas, but from infiltration galleries which extend for about 5½ miles parallel to the city's conduit.

The distribution of draft from different well fields and also from the different formations changes from time to time, so that a map similar to figure 6 for any other year would present a different aspect. Among changes since 1930 the following may be noted. The Bayside plant of New York City has been abandoned; wells have been drilled to the Cretaceous beds at the city's Flushing steam station; the post-Jameco wells of the Freeport and Hempstead municipal stations have been abandoned or are held only for emergency; a new supply from Cretaceous beds has been developed for the village of Old Westbury; and the quantity of water taken from the Jameco gravel at Locust Valley has diminished with an increase in the draft from the Cretaceous beds. Despite these changes, figure 6 shows in a general way the most significant features of the geographic and geologic distribution of withdrawals of water for public supply in the three counties.

The preceding table and figure 4 show that by far the largest quantity of water withdrawn for public supply in each of the counties has come from the post-Jameco beds, undoubtedly in part because these beds are most widespread and nearest the surface and thus are most easily developed, but also perhaps in part because they yield water in large quantities. For the whole period the next largest quantity has come from the Cretaceous beds, but this quantity is very much smaller than that from the post-Jameco beds. The Cretaceous beds occur beneath practically all of Nassau County and the eastern and southeastern parts of Queens County, but are absent in much of Queens County and in a large part of Kings County. The quantity of water taken from the Jameco beds is only slightly less than that taken from the Cretaceous beds, and during the early part of the period it was somewhat greater.

Certain significant facts in regard to the geographic and geologic distribution of withdrawals and changes in such distribution from time to time may be discussed briefly.

Throughout the period 1904 to 1934 most of the water taken from wells in Kings County for public supply came from the post-Jameco beds. The next largest quantity came from the Jameco gravel, which is well developed in the area of the old Sound River Valley. In recent years there has been a marked increase in the quantity of water taken from the Jameco gravel, together with a decrease in the quantity taken from the post-Jameco beds, in part as the result of abandonment of shallow post-Jameco wells and drilling to the deeper Jameco gravel in the Flatbush territory, in an effort to avoid the danger of pollution in areas that are highly built up. It also may be due in part to the reduction in pumping of shallow wells in certain areas where the chloride has increased to such an extent that the water cannot be used for domestic purposes. The quantity of water taken from the Cretaceous deposits in Kings County has always been small, because those deposits are absent in a large part of the county. It is estimated that in 1933 about 50,000,000 gallons a day was taken from private wells for industrial use in Kings County. The greatest part of this was withdrawn in the northern part of the county, mostly from the post-Jameco beds or the Jameco gravel. A very few wells in the southern part of the county, in and near Coney Island, draw from the Cretaceous beds.

In Queens County more water has been taken from the post-Jameco beds for public supply than in Kings County. However, as shown in figure 5, the percentage of water withdrawn from post-Jameco beds in Queens County has been less than in Kings County except in the last few years. There has not yet been any marked tendency to reduce the draft from post-Jameco wells in Queens County, as has occurred in Kings County. The quantity of water taken from the Jameco gravel in Queens County for public supply has also been considerably greater than that taken from this gravel in Kings County. The Jameco gravel is well developed along the course of the old Sound River Valley in parts of Queens County. The quantity of water taken from the Cretaceous deposits in Queens County for public supply has been slightly less than that from the Jameco gravel. However, since 1916, except in two years, the Cretaceous pumpage has exceeded the Jameco pumpage. Well fields for public supply in Queens County are confined almost wholly to the eastern and southern parts of the county, in part because bedrock lies not far below the surface in the northwestern part of the county and the unconsolidated beds are either not very thick or do not yield water

abundantly. The Cretaceous beds have been completely removed from much of the western and northwestern parts of the county. The draft from industrial wells scattered throughout Queens County is estimated to have been about 25,000,000 gallons a day in 1933. The relative quantities taken from the different formations for industrial use have not been determined, but they are probably similar in proportion to the withdrawals for public supply in the County.

The quantity of water taken from the post-Jameco beds in Nassau County during the period 1904 to 1934 was greater than that taken from the same beds in the other two counties together. However, from 1917 to 1934 slightly more water was taken from post-Jameco beds in Kings and Queens Counties together than from Nassau County. Prior to 1917 a large part of the water considered to come from the post-Jameco beds in Nassau County was obtained from the ponds. The quantity of water taken from the Jameco gravel in Nassau County has been very small and has practically all come from a few localities near the north shore. This is because the Jameco gravel is absent over much of Nassau County or at least has not been recognized as such in this part of the island. During most of the period the quantity of water taken from the Cretaceous beds in Nassau County has been comparatively small, but beginning about 1926 there was a marked increase in the draft on these beds, at the expense of the draft from the post-Jameco beds. A considerable number of wells have been drilled to the Cretaceous beds, and several well fields drawing from the post-Jameco beds have been abandoned or are merely held for emergency use.

As shown by figure 5, during the period 1904 to 1934, in each of the three counties as well as in the area as a whole, the percentage of water taken from each of the three source formations has varied. This variation has been due in part to variations in the withdrawal of water by New York City, which in turn has been due chiefly to variations in the quantity of water available from its upstate sources. The most notable fact shown by figures 4 and 5 is that in recent years there has been an increase in both quantity and percentage of water taken from the Cretaceous beds in Queens and Nassau Counties and from the Jameco gravel in Kings County. However, it is possible that New York City will draw increasingly from its well fields on Long Island for several years, until its next large upstate surface water development is completed. If this happens it seems likely that in the near future the recent increase in draft from the Cretaceous deposits--both in quantity and in percentage of the total--may be overshadowed by further marked increases in the draft from the two shallower formations, because the city's well fields on Long Island draw largely

from the post-Jameco beds and to a less extent from the Jameco gravel.

The withdrawals in Suffolk County have not been fully analyzed, but it is evident that the percentage of total pumpage from the different source formations is, in general, the same as in the western part of the island, in that probably more than half of the pumpage comes from the post-Jameco beds and that the percentage from the deeper water-bearing beds has increased in recent years. A relatively large quantity is withdrawn from Cretaceous beds, notably at the United States Veterans Administration hospital near Northport and the State hospitals at Kings Park and Central Islip. Only a small quantity is definitely known to come from Jameco beds, but when more data are available to permit a more accurate correlation of the formations in the eastern part of the island it may be shown that the pumpage from the Jameco beds is greater.

The increasing draft on the deeper formations, particularly the Cretaceous beds in many parts of Long Island, during recent years deserves special consideration. This may be attributed principally to the desire and in some localities the proved necessity of avoiding the danger of contamination both by bacterial pollution and by intrusion of salt water into the upper formations that are not protected by an impervious clay. The trend shown by figures 4 and 5 is significant, for if it continues obviously more attention should be given to the danger of exceeding the safe yield of the deeper water-bearing formations. In the past quantitative studies of the safe yield of the water-bearing formations of Long Island have considered primarily only the post-Jameco beds. They have not given adequate attention to the complicated but important influence of such factors as the permeability and intake facilities of the deeper beds and the communication or lack of communication of these beds with the upper beds. These are problems to be considered in subsequent reports.